

## ASIAN FLOODING INDUCED BY MARINE WINDS

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### Abstract

The methodologies of estimating both ocean surface winds vectors over the ocean and the flooding index over land by spaceborne scatterometers are described. Backscatter data from the SeaWinds scatterometer on the QuikSCAT mission are used to depict the monsoons and tropical cyclones which brought excessive moisture into the Asian continent and monitor the subsequent flooding over land during summer and fall of 1999.

### 1. Introduction

Floods destroy crops, properties, and lives. In Asia, floods are usually resulted from excessive moisture brought in from the oceans by monsoons or tropical cyclones. In the developing countries, the infrastructure to collect and disseminate weather and flooding information is not adequate. Spacebased instruments may provide timely and large-scale monitoring of the moisture advection and the extent of flooding.

### 2 Marine Winds

Both wind speed and direction over global oceans are being monitored by spaceborne scatterometers. A scatterometer sends microwave pulses to the Earth's surface and measures the backscatter power from the surface roughness. The roughness may describe characteristics of polar ice or vegetation over land. Over the ocean, which covers more than three-quarters of the Earth's surface, the backscatter is largely due to small (centimeter) waves on the surface. The idea of remote sensing of ocean surface winds was based on the belief that these surface ripples are in equilibrium with the local wind stress. The backscatter power depends not only on the magnitude of the wind stress but also on the wind direction relative to the direction of the radar beam. The capability of measuring both wind speed and direction is the major uniqueness of the scatterometer. Because the atmosphere is largely transparent to microwaves, radar scatterometers are able to provide daily coverage of the global oceans, under both clear and cloudy conditions.

Monsoons are the seasonal change of wind forced by continent-ocean temperature contrast. Liu and Xie [1998] use scatterometer data to compare the oceanic responses to the annual variation of monsoon in the Arabian Sea and South China Sea. Liu et al.

between surface wind convergence and the hydrologic balance of Hurricane Floyd. Scatterometers are capable of monitoring not only the ocean winds, which feed moisture towards land, but the consequent flooding of the land.

### **3 Flooding Index**

Attempts have been made to detect flooding by other spacebased sensors with less success. Visible and infrared sensors are obscured by clouds. Passive microwave sensors have high noise-to-signal ratio and have poor spatial resolution. Synthetic aperture radars (SAR) have high spatial resolution but narrow swath and small coverage. A spaceborne wide-swath scatterometer works night and day, under clear and cloudy conditions, with higher resolution than radiometer and better coverage than SAR.

Both scattering and reflection from the surface contribute to the backscatter energy received by the scatterometer. Over dry land, scattering dominates and the horizontal polarization return (H) is smaller than the vertical polarization return (V). When the land gets flooded, however, the reflectivity of the surface increases greatly, and H becomes larger than V. The difference between reflectivities in H and V increases with incident angle, up to  $80^\circ$ . Over flooded land, the ratio  $V/H$  is less than 1 in the linear scale or negative in the dB scale, as opposed to the dry case. The total backscatter (sum of scattering and reflection) may not change significantly because increase in reflection may be balanced by decrease in scattering.

A Ku-band (13.4 GHz) scatterometer SeaWinds was launched on NASA (National Aeronautics and Space Administration) Mission QuikSCAT in June 1999. SeaWinds measures H at a constant incident angle of  $54^\circ$  over a swath of 1800 km and V at  $46^\circ$  over a 1400 km swath, providing a large difference in reflectivity. It is more conducive to monitor flooding than previous scatterometers, with varying incident angles.

### **4 Mapping Floods in 1999**

The ratio of the vertical to the horizontal backscatter coefficients over flat terrain is a good indication of flooding extent, and it is mapped in Fig. 1. QuikSCAT observations coincide with extensive floods in Asia caused by strong monsoons and tropical cyclones. The maps in Fig. 1 show that the flooding in the Yangtze Valley of China ( $30^\circ\text{N}$ ), represented by blue patches, is clearly visible in July, following strong summer monsoons. The flooding observed in Anhui, Zhejiang, and Jiangsu provinces agrees with reports by the International Federation of Red Cross. The flooding recedes in September, with the retreat of the summer monsoon and the advance of the winter monsoon. The intensity of the flooding increases again in October, after the landfall of a typhoon. The flood in Bangladesh and east India did not start until August but continues to strengthen through October. The most severe floods in Vietnam, Thailand, and Burma occurred in August and September, at the peak of summer monsoons. By the end of the year, all the flooding disappears.

In October 1999, two tropical cyclones (TC) developed in the Bay of Bengal. TC04 landed in the Ganjam district in India, on October 17, 1999, and moved inland. TC05B landed near Bhubaneswan, India, on October 29, but moved out to the sea again shortly afterward. Fig. 2 shows that TC04B covers a larger area and because it moved further inland, it caused more extensive flooding than TC05B.

## 5 Future Plan

Timely flood mapping provides critical information to help relief effort and to assess economic and ecological consequences. We plan to display and disseminate near-real-time flood indexes over selected regions in our website <http://airsea-www.jpl.nasa.gov/seaflux> in the future.

## Acknowledgment

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## References

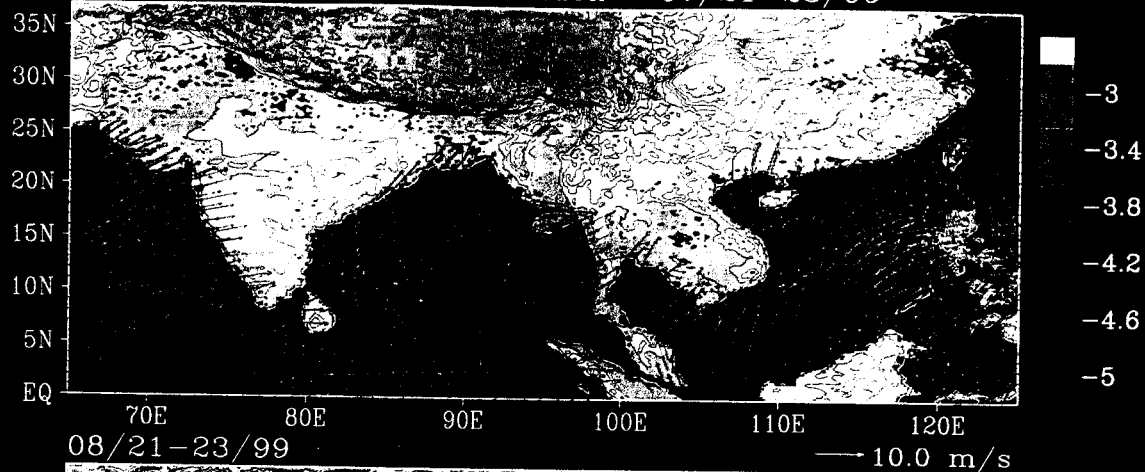
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### Figure Legends.

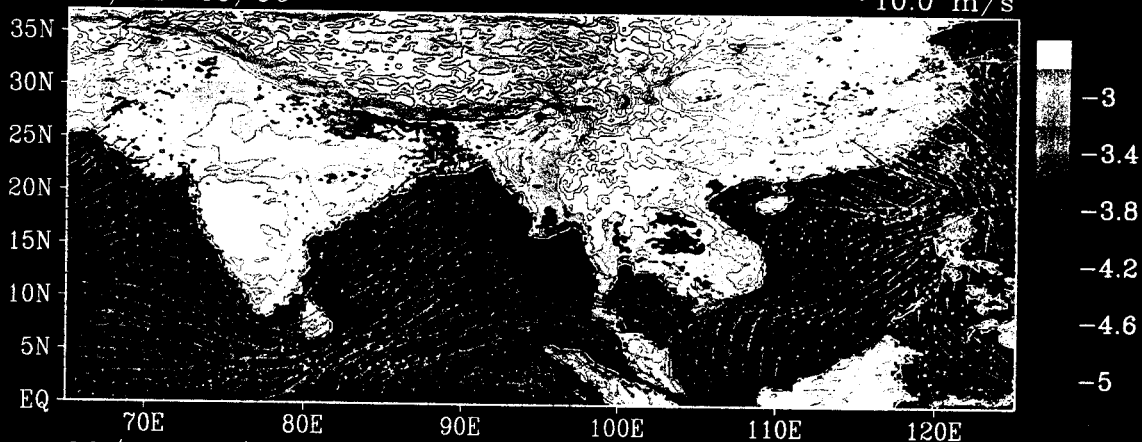
Fig. 1 Three-day average wind vectors over ocean and flood indexes over land derived from SeaWinds on QuikSCAT observations, for four months in 1999 (from Liu et al., 2000b). Topographic map for areas over 5-m elevation is plotted over flood indexes.

Fig. 2 Ocean wind vectors (dark arrows) from QuikSCAT superimposed on surface precipitation (color image) from TMI for Tropical cyclones 04B (left) and 05B (right) in the top row. Three-day averages of flood index, covering the same periods, are plotted in the bottom row, similar to Fig. 1. The color image representing wind speed and white arrows representing wind direction, both from QuikSCAT, are shown over the ocean

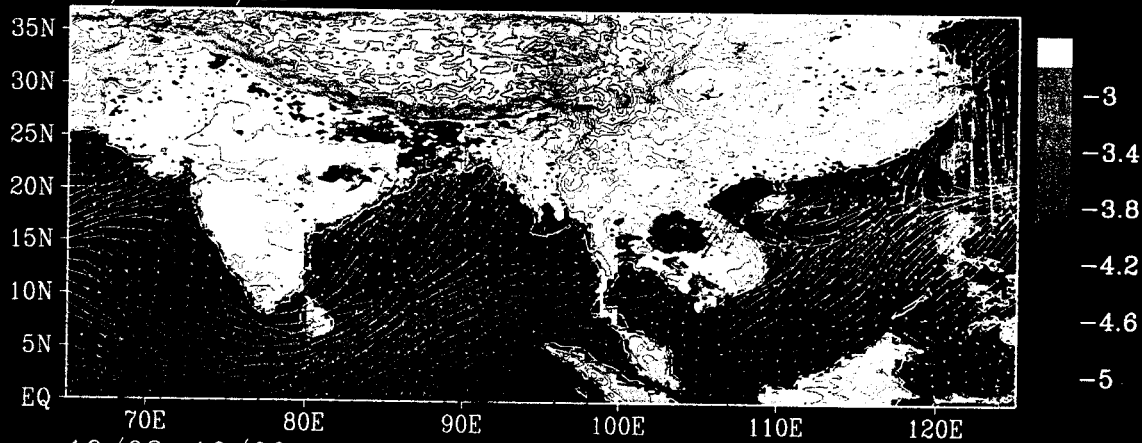
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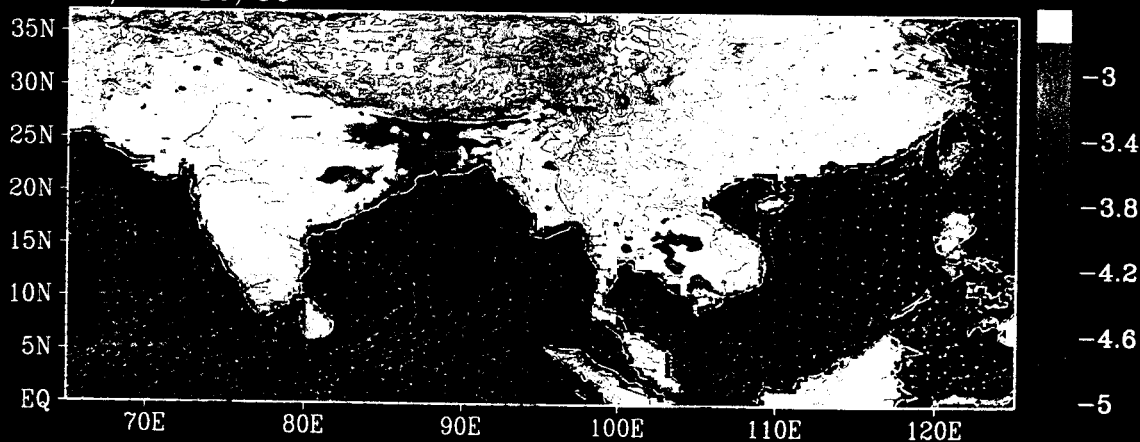
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